Examining into its merits, it is readily seen that this method, as previously stated, is open to several serious objections: phosphate of aluminium is quite soluble in an excess of acetic acid; the precipitate of the phosphates of iron and aluminium is very apt to carry with it some of the calcium salt; the precipitate of the iron and aluminium obtained is not necessarily pure normal ortho-phosphate; and, finally, there is a great risk of introducing an error in calculating the combined phosphates of iron and aluminium over to the sesqui oxides.

The molecular masses of the compounds concerned are:—

$$\begin{aligned} Fe\,PO_4 &= 151 \\ Al\,PO_4 &= 122 \\ Fe_2\,O_3 &= 160 \\ Al_2\,O_3 &= 102 \end{aligned}$$

If the constituents, the iron and the aluminium phosphates, occur in the precipitate in the proportion of their respective molecular masses, i.e., 151 : 122, no error will be committed in assigning to this precipitate of the mixed phosphates the formulæ, ($Fe\,PO_4 + Al\,PO_4$), and calculating to $Fe_2\,O_3$, as is shown by the following example. Assume the composition of the precipitate to be:—

$$\begin{aligned} Fe\,PO_4 &= 0.151 \\ Al\,PO_4 &= 0.122 \\ \hline Fe\,PO_4 + Al\,PO_4 &= 0.273 \end{aligned}$$

Calculating the combined phosphates over to the combined oxides:—

$$2\,(Fe\,PO_4 + Al\,PO_4) : (Fe_2\,O_3 + Al_2\,O_3) :: .273 : x$$
$$546 : 262 :: .273 : x$$
$$x = 0.131$$
$$\text{i.e., } (Fe_2\,O_3 + Al_2\,O_3) = 0.131$$

Calculating the $Fe\,PO_4$ and the $Al\,PO_4$ separately over to their respective oxide, and then adding them:—

$$2\,Fe\,PO_4 : Fe_2\,O_3 :: 0.151 : x$$
$$302 : 160 :: 0.151 : x$$
$$x = 0.080 \quad Fe_2\,O_3$$
$$2\,Al\,PO_4 : Al_2\,O_3 :: 0.122 : x$$
$$244 : 102 :: 0.122 : x$$
$$x = 0.051 \quad Al_2\,O_3$$

$$\begin{aligned} &0.0800\ Fe_2\,O_3 \\ &0.0510\ Al_2\,O_3 \\ \hline &0.1310\ Fe_2\,O_3 + Al_2\,O_3, \end{aligned}$$

which is identical with the value previously obtained. If, however, the iron phosphate and the aluminium phosphate are present in a proportion different from the one assumed in the above example, the result obtained by calculating their combined weight to combined oxides is wrong. It will be too high or too low, accordingly as the iron, aluminium, or the phosphate predominates.

Example.— Assume that the combined phosphates weighed exactly the same as before = 0.273 gramme; but assume the composition of the precipitate to be:—

$$\begin{aligned} Fe\,PO_4 &= 0.219 \\ Al\,PO_4 &= 0.054 \\ \hline &\ \ 0.273 \end{aligned}$$

Calculating the combined phosphates over to the combined oxides, of course the same result as previously found will be obtained, namely, that

$$\underset{(Fe\,PO_4 + Al\,PO_4)}{0.273} = \underset{(Fe_2\,O_3 + Al_2\,O_3)}{0.131}$$

But calculating the $Fe\,PO_4$ and the $Al\,PO_4$ separately to their respective oxide, there is found:—

$$\begin{aligned} &Fe\,PO_4 \quad 0.219 = 0.1160 \quad Fe_2\,O_3 \\ &Al\,PO_4 \quad 0.054 = 0.0225 \quad Al_2\,O_3 \\ &\left.\begin{matrix} Fe\,PO_4 \\ + \\ Al\,PO_4 \end{matrix}\right\} 0.273 = 0.1385 \left\{\begin{matrix} Fe_2\,O_3 \\ + \\ Al_2\,O_3 \end{matrix}\right. \end{aligned}$$

a higher result than obtained above.

If the composition of the same weight of the combined phosphates of iron and aluminium be assumed to consist of

$$\begin{aligned} Fe\,PO_4 &\ \ 0.054 \\ Al\,PO_4 &\ \ 0.219 \\ \hline &\ \ 0.273 \end{aligned}$$

there will result as before:—

$$\underset{(Fe\,PO_4 + Al\,PO_4)}{0.273} = \underset{(Fe_2\,O_3 + Al_2\,O_3)}{0.131}$$

But,

$$\begin{aligned} &Fe\,PO_4 \quad 0.054 = 0.0286 \quad Fe_2\,O_3 \\ &Al\,PO_4 \quad 0.219 = 0.0915 \quad Al_2\,O_3 \\ &\left.\begin{matrix} Fe\,PO_4 \\ + \\ Al\,PO_4 \end{matrix}\right\} 0.273 = 0.1201 \left\{\begin{matrix} Fe_2\,O_3 \\ + \\ Al_2\,O_3 \end{matrix}\right. \end{aligned}$$

a value considerably lower than obtained by the other method of calculation.

Method II. makes a much better showing than the preceding method. The chief objection to it, is the error involved in weighing the iron and the aluminium as phosphates and calculating them to the oxides, as explained above.

This difficulty, however, could be obviated in the following manner:—

Proceed with the analysis exactly as directed, and weigh the iron and the aluminium as phosphates; then dissolve in $H_2\,SO_4$; reduce the iron by means of zinc and platinum in a $H_2\,SO_4$ solution; titrate with standardized $K_2\,Mn_2\,O_8$ solution, and record the iron as $Fe_2\,O_3$; calculate this to iron phosphate, $Fe\,PO_4$; subtract this value from the weight of the combined phosphates, and then calculate the remainder, the $Al\,PO_4$ to $Al_2\,O_3$.

Method III. has certainly yielded the most satisfactory result, for the difference between the amount of the iron and the aluminium oxides present and determined is only 0.04 per cent, a difference corresponding to less than two-tenths of a milligramme in the actual weight of the precipitate, $Fe_2\,O_3 + Al_2\,O_3$, in this experiment.

The feature which serves as the special endorsement of this method is the fact that the constituents sought are reported in the very form in which they are weighed, and that thus the introduction of errors by calculation is excluded.

In order to test the working of these three methods in actual practice they were applied to the analysis of four samples of bone black.

The results obtained follow:—

Sample.	Method I.	Method II.	Method III.
1	0 65	0.47	0.47
2	0.50	0.44	0.54
3	0.58	0.41	0.46
4	0.43	0.36	0.38

OSTEOLOGICAL NOTES.

BY DANIEL DENISON SLADE, M.C.Z., CAMBRIDGE, MASS.

THE jugal arch in the order of the Cetacea presents some singular modifications. In the Delphinoidea, the squamosal, frontal, and jugal enter into its composition. The squamosal sends forward a large, bulky process which nearly meets the descending post-orbital process of the frontal. The jugal is an irregular flat bone, covered by the maxilla, and sends back from its anterior and internal border a long and very slender process, curved slightly downwards, to articulate with the short, obtuse process of the squamosal, thereby forming the lower boundary of the orbit.

So far as the relations of the squamosal and jugal are concerned, the portion of the arch thus formed is a counterpart of that of the horse; although the union of the two bones is much more complete in the latter animal. The jugal in the horse is relatively a much larger bone, and sends back a well-developed process which underlies that of the squamosal, with which it is joined by a

nearly horizontal suture, thus forming a strong suborbital bony wall.

In the Delphinoidea, the delicate character of the suborbital process of the jugal, and its union with the squamosal, render it difficult at first sight to determine its relation to the arch, and yet, when compared with that of the horse, its homological character cannot be disputed.

In the Balænoidea, much the same conditions are presented, except that the suborbital process of the jugal is both stronger and more curved. The small capacity of the temporal region, as well as the limited extent of the arch in the Cetacea, are correlated with the modifications presented by the mandible, in which the condylar surface is small, and looks directly backwards. There is no ascending ramus, and the coronoid process is quite rudimentary, — all of which conditions are in direct relation to the nature of the food, and absence of the masticatory movements.

The jugal arch in the Sirenia is enormously developed, being composed of the squamosal and the jugal. The former of these is much thickened and presents upon its external face a smooth convex surface.

In the Manatus, this process of the squamosal rests loosely upon the process of the malar, which, underlying it, extends back as far as the glenoid, having first formed a rim which is both suborbital and post-orbital, besides sending a broad plate downwards and backwards, thereby greatly increasing the vertical breadth. The orbital fossa is separated almost completely from the temporal by a bony partition.

The surface for the muscular attachments, both of the temporal and masseter, are extensive, while the pterygoid plates and groove are relatively enlarged. The vertical curvature of the arch is great, but the horizontal is inconsiderable. The ascending ramus of the mandible is broad, compressed, with rounded angle, and surmounted by an obliquely-placed small convex condyle, much raised above the molar series. The coronary surface is broad, directed forwards, and but slightly elevated above the condyle.

In the Dugong (Halicore), the jugal arch is much less massive; there is no post-orbital process from the jugal, and consequently no separation of the orbital and temporal fossæ by a bony orbit. The coronoid process of the mandible looks backward.

Although the horizontal curvature of the arch is very slight in both genera of the Sirenia, the temporal fossæ are deepened and extended — conditions owing to the walls of the cranium being compressed in a lateral direction, which materially increases the extent of surface for muscular attachment and development.

In the order Edentata, the jugal arch also offers unusual modifications. In the Myrmecophagidæ it is very incomplete, being composed of the proximal end of the jugal, articulating with a narrow projecting process of the maxilla, and a very rudimentary fragment of the squamosal. These separate portions, however, do not meet. In fact, they are widely separated. No boundary exists between the orbital and temporal fossæ, the latter being comparatively shallow. The glenoid fossa is a shallow cavity running antero-posteriorly, and well adapted to the pointed, backward projecting condyles of the mandible, whose long, straight horizontal rami present neither coronoid process nor angle. In Cycloturus, the mandible is somewhat arched, and presents a well-marked angular process, as well as coronoid surface slightly recurved.

In the Bradypodidæ, containing the two species Bradypus and Cholœpus, the arch is imperfect, consisting of the jugal, which is narrow at its articulation with the lacrymal and maxilla, but which, widening out into a broad, compressed plate, terminates posteriorly in two processes, the upper pointing backwards and upwards, while the lower looks downwards and backwards. The straight process of the squamosal, although fairly developed, fails to meet either of those of the jugal. There is a post-orbital process of the frontal, which is best marked in Cholœpus. The glenoid is shallow and narrow from side to side. The mandible, widest in Cholœpus, develops a rounded convex condylar surface, well raised up from the dental series, while the coronoid surface is large and recurved. The rounded angular process projects backwards to a considerable extent. The symphysis in both species is solidified, while in Cholœpus it projects forwards into a spout-like process. The temporal surface for muscular attachment is large, as are also the pterygoid plates.

In the Dasypodidæ, the arch is complete, and in its formation the jugal largely enters. This bone extends from the lacrymal and frontal to the process of the squamosal, the anterior third of which it underlies. There is no post-orbital process of the frontal. The glenoid presents a broad, slightly convex, transverse surface. The pterygoids are small. The mandible has a high ascending ramus, the condyle is transverse and high above the alveoli, while the coronoid surface is large and the angle broad and projecting.

In the Manidæ, the jugal arch is incomplete, owing to the absence of the malar, which, if present would occupy almost the exact centre of the arch,—the length of the squamosal process, and that of the maxillary, being nearly equal on either side. The temporal and orbital fossæ form one depression in the side of the skull. The rami of the mandible are slender and straight and without teeth, angle, or coronoid process. The condyle is not raised above the level of the remainder of the ramus.

In the Orycteropidæ the jugal arch is complete. The horizontal curvature is very slight. The post-orbital process is well developed. The mandible rises high posteriorly, with a coronoid slightly recurved, and with an ascending pointed process on the angular edge below the condyle.

In the Marsupialia, the jugal arch is always complete, and composed of the jugal, resting on the maxilla, and squamosal, the first extending from the lacrymal anteriorly to the glenoid fossa posteriorly, of which it forms the external wall. The process of the squamosal passes above the jugal, being united to it by an almost horizontal suture. The horizontal and vertical curvatures of the arch are considerable, and the space for both temporal and masseter muscular insertions is extensive, and the various ridges and crests are extensive, especially in the families of the Dasyuridæ and Didelphyidæ. The post-orbital of the frontal is present as a rule, although in most forms inconsiderably developed. The ascending ramus of the mandible is less elevated than in several of the orders of the Mammalia. The condyle is but little raised above the molar series. The masseteric fossa is extremely projected at its lower external border. The mandible has, with one exception, an inverted border to the angle.

In the Monetremata, the Echidnidæ possess an arch in which the squamosal is compressed, and sends forward a slender, straight process to join the corresponding slight, shaft-like process of the jugal. The horizontal curvature of the arch is extremely small.

In the Ornithorynchidæ, the arch is made up of the malar resting upon a process of the maxilla, which, passing straight backwards, unites with the squamosal process that rises far back on the sides of the cranium. While the mandible of the Echidna has but the rudiments of the parts which usually enter into its formation, that of the Ornithorynchus is more fully developed, in relation to the attachment of the horny teeth.

LETTERS TO THE EDITOR.

*** *Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

On request in advance, one hundred copies of the number containing his communication will be furnished free to any correspondent.

The editor will be glad to publish any queries consonant with the character of the journal.

The Mean Distance of the Earth.

THE interlinear readings to Sir Robert S. Ball's "The Course of an Ice Age" which Miss Hayes gives in *Science* for April 28 have been read and studied with much grateful appreciation by some readers of that book who find the higher mathematics rather slippery ground to walk on without help. On behalf of a group of such readers, I wish to say a few words on the interlinear reading given for the first selection from Sir Robert's book.

The passage is: "There can be no doubt that when the eccentricity is at its highest point the earth is, on the whole, rather nearer the sun, because, while the major axis of the ellipse is un-